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INTERPRETATIONS OF MEASUREMENTS OF
AUDITORY THRESHOLDS

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INTERPRETATIONS OF MEASUREMENTS OF AUDITORY THRESHOLDS

By

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Progress Report No. 1

Bureau of Medicine and Surgery
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"The Estimation of Percentage
Hearing Loss From Pure Tone Audiogram"

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INTERPRETATIONS OF MEASUREMENTS OF AUDITORY THRESHOLD

The vocational guidance expert need not be personally acquainted with the techniques of administering hearing tests as outlined in a previous chapter, but he should be able to judge the value of the results from a particular test, and in the case of a satisfactory test he should be able to interpret results in terms of the occupation he is considering.

The classical methods of testing hearing are practically obsolete. Research has shown that the variability of such relatively uncontrolled tests as the tuning fork, watch tick, coin click, and spoken and whispered voice, are of almost no value for the correct placing of a person's hearing. Certain of these tests may be valuable from a clinical point of view, but this value is of no concern to us here. Three satisfactory tests of hearing are becoming more and more widespread:

1. The pure tone audiometer, an instrument which generates pure tones over a wide range of frequencies. Pure tones are used because of the fact that many ears hear certain frequencies very well, but other frequencies very poorly. A person may have good high-tone hearing but poor low-tone hearing, or the reverse. Hence, a number of frequencies must be tested in order to determine the overall functional efficiency of an ear. For any frequency, the subject is required to indicate the lowest intensity he can hear. Usually the frequencies selected are the octaves from 256 cycles per second (Middle C on the piano keyboard) to 8192 c.p.s.

In order to protect the legal rights of a person entering an occupation possibly injurious to the ear, an audiogram should in all such cases be provided. Hearing may be damaged to some extent, but not sufficiently to be detected by the usual coarse test. The audiogram will detect the least damage. Moreover, hearing may be damaged for certain frequencies but not for others, and the undamaged frequencies may be sufficient for the patient to pass the usual hearing test and the loss go undetected. Yet even this loss is a matter of compensation as it may lead to later disturbances of hearing. Only the audiogram will uncover this state of affairs. Without a previous audiogram the person cannot claim the

hearing loss was occasioned by that occupation. On the other hand, the employing company is protected by an early audiogram, since otherwise an employee could claim compensation for a hearing deficit which may have existed before the work but was undetected.

2. Voice tests, where all that is desired is an estimate of a man's ability to understand speech, no better test can be devised than the use of the human voice. However, for accurate, usable results, the voice intensity must be regulated by means of certain apparatus. The most common form is the Western Electric Phonograph Audiometer test, consisting of digits which grow weaker and weaker in intensity as the record progresses. The subject is required to write down as many digits as he can hear. Fairly satisfactory results are obtained with this equipment; standards of hearing have been collected on many thousands of ears. The interpretation of results from this test can be made by the vocational counselor from the data which is printed on the score card. Subjects are labelled normal, somewhat below normal, or in need of a hearing aid. The counselor can judge at once how well the subject will perform in an occupation demanding good speech intelligibility.

3. In a few places the intensity of the voice is governed by means of a voice level monitoring system. This is true for the large Army and Navy aural rehabilitation centers. The tester speaks into a microphone leading to the subject's loudspeaker, and keeps his voice at a constant level by watching an output voltmeter. The speech is then lowered in intensity by inserting more and more resistance into the electronic circuit. The level is found at which subjects with known normal hearing as tested by the audiogram can hear speech. Subjects with defective hearing are described as so many intensity units below this standard level. Very accurate placement of hearing ability can be made. The results for any subject will be in terms of decibels below the normal level. The counselor can interpret these figures in more conventional terms as described in Table 1 and in the next paragraph.

In order to conform to medical and legal practice, it is necessary to speak of hearing disability in terms of percentage loss. Scores from a phonograph test or a monitored voice test should be converted into percentage hearing loss before interpretation is made. Also, many doctors report

scores in terms of a fraction of which the denominator is the distance in feet at which a normal ear can just hear the sound used, the numerator is the distance at which a deafened ear can hear that sound. Thus, a score on a voice test of 10/15 means that that ear must be within 10 feet of a voice which a normal ear can hear at 15 feet. This distance-fraction must also be converted into percentage hearing loss.

Some of these relationships are described in Table 1. In the first column is found a classification of hearing in everyday terms. The second column presents percentage hearing loss for speech calculated from the pure-tone audiogram according to the method recommended by the American Medical Association. Column 3 presents the average loss in decibels as determined by the audiometer for the speech range of 512-2048 c.p.s. The counselor can quickly compute this value when faced with the problem of interpreting an audiogram; the average loss thus computed may be translated into percentage hearing loss by comparing the figure with column 2 of Table 1.

Column 4 presents the loss in hearing of actual speech, either monitored or by phonograph. A defective ear is said to function at levels so many decibels (a unit of intensity) worse than normal ears. Table 1 directly translates decibel loss into percentage hearing loss.

Column 5 & 6 represent the usual relatively uncontrolled clinical tests using the actual voice. The bottom figure of the distance-fraction is the distance at which a normal ear can just hear speech, and the top figure is the distance at which the defective ear can just hear that same speech. Table 1 translates these data into other terms.

LEVELS OF HEARING FOR SPEECH INTELLIGIBILITY

1. Necessity for understanding the human voice: It is generally considered that a person whose loss is greater than 30% in the better ear should be referred for the fitting of a hearing aid. An individual deafened by 30% may be brought to a perfectly normal level with a well-fitted instrument.

2. In order to hear subdued conversation in a quiet room, an ear must have no worse than 15% loss. A person worse

TABLE I
Conversion Table for Scores of Speech Intelligibility

General Classification	Percentage Hearing Loss for Speech ¹	Average Audiogram Loss in Decibels at 512, 1024, and 2048 c.p.s.	Decibel Loss Below Normal Level of Speech ²	Spoken Voice Distance-Fraction ³	Whispered Voice Distance-Fraction ⁴
Normal or Near-Normal	0	0	0	15/15	no reliable data
	1-9	7	6	15/15	15/15
	10-19	17	16	14/15	15/15
Somewhat hard of hearing	20-29	30	26	10/15	7/15
	30-39	42	36	6/15	3/15
Needs hearing aid for effective social intercourse	40-49	52	46	4/15	5/15
	50-59	65	56	3/15	no reliable data
	60-69	77	64	1/15	
	70-79	no reliable data	74	.75/15	
	80-89		80	.5/15	
	90-99			0/15	
100					

Each column independently calculated.

¹Calculated from audiogram by American Medical Association method of computing percentage loss.

²Data from phonograph voice test and monitored voice test: both tests give similar results.

³Data adapted from Fowler, E. P., Sr., Hearing Standards for acceptance, disability rating and discharge in the military services and in industry. Laryngoscope, 1941, 51, 937-956.

⁴No scores can be obtained representing loss of less than 20 db in the usual testing situation with a noise level of 20-30 db as found in the usual testing alley.

than this will miss 25% or more of speech sounds and will occasionally be forced to request a sentence repeated.

3. For those occupations demanding excellent conversational intelligibility (for example, physicians, undertakers) hearing should be at least within 5% of normal.

It may be thought that these standards are somewhat stringent; but it must be remembered that the pathology of deafness is almost invariably progressive, such that a person with a 15% loss in childhood, although undetected at that time, will almost certainly grow worse and ultimately require a hearing aid.

LOUDNESS LEVELS AND MASKING

The problem of auditory functioning is complicated by the fact that an ear may perform poorly at low loudness levels, but if the loudness level be increased, the ear may function as well as a perfectly normal ear. For example, a person may be defective in understanding the whispered voice, yet be perfectly capable of understanding conversation at higher intensities. Another complication arises from the fact that ears differ in their ability to function under high background noise masking. Consequently, in occupations where speech is at loud levels or where masking noise is presented, certain tests in addition to a threshold measurement must be made. Occupations where these factors are of particular importance, are many of those involving communication systems where a high degree of noise and distortion is present in the equipment, divers, radiomen, telegraph and telephone operators, and aircrew men. In order to test these abilities, it is necessary either to provide a hearing examination under the actual conditions of the job in question or some very similar hearing test. One test available is a phonograph record test consisting of words spoken in a background noise; the latter reproduces the noise spectrum in the cabin of a B24 bomber. If a person can score average or better on this test, the likelihood is that he can overcome masking and distortion satisfactorily on the job. This test is available as Auditory Test No. 8, Psycho-Acoustic Laboratory, Harvard Univ. The interpretation of the test must be in terms of a group of men successful in the performance of the job in question.

PITCH AND LOUDNESS DISCRIMINATION

There are certain occupations where the quite specialized auditory functions of pitch discrimination and loudness discrimination are of some importance. For example, mechanics pay considerable attention to slight differences in the noise produced by machinery, and, for determining these changes, at least average discriminatory ability must be present. In piloting a small airplane, there are certain maneuvers in which attention to motor noise, slip-stream sounds, and the noise of certain rigging may be significant.

There are certain indications from recent research that speech intelligibility is related to good pitch and loudness discrimination. As yet, however, the Bell Telephone Laboratories have not published their results in final form.

There are certain occupations in which good pitch discrimination is a primary requisite--these include mine-sweeping, operation of sound detection gear, the use of the expendable radio sonic buoy, and piano tuning. For these occupations, the man should stand well up on the test.

OTHER AUDITORY FUNCTIONS

Certain other auditory functions are present and distinguishable by common tests and must be taken into account particularly for the playing of musical instruments. For this purpose a very reliable and well validated series of records is available and should be used much more widely than is commonly the case.

INTERPRETATIVE RESPONSES

The six primary musical abilities which have so far been distinguished are the discrimination of pitch, loudness, time, timbre, rhythm, and tonal memory. Each of these abilities can be tested with a single phonograph record by means of the Seashore Measures of Musical Talent. These records have been standardized on many hundreds of children so that adequate interpretative statistics are available. These records are obtainable at any good music store and require only a slight amount of instruction to administer. Scores are made a matter of record for all the children of many school systems in this country. It is not possible to say from a low score on one or two of these tests that a child

will make a poor musician, since an individual may compensate in a surprising number of ways for deficiency in one function; but it is possible to say that if a person's score is above average on these tests he has the fundamental auditory abilities for good musicianship, other things being equal.

Two forms of this test are available: Form A--a relatively coarse screening test applicable for group testing and Form B--in which the items are more difficult than in Form A and consequently provide a finer check on the subject's ability. Form B is arranged for individual administration only.

In counseling anyone with regard to music as a profession or even as a serious hobby, results of the Seashore Measures should certainly not be overlooked.

THE USE OF RESIDUAL HEARING

In counseling an individual with deafened hearing it is not necessary to adopt a pessimistic or defeatist attitude. In the first place there is only a small fraction of individuals who are so deaf that no improvement can be effected by a properly fitted hearing aid. Modern electronic methods have already advanced and will advance still further, to the point where a perfectly normal existence is possible for those for whom nothing could be done 5 years ago. For these individuals it would not be justified to suggest that they refrain from considering certain occupations for which they are otherwise fitted by ability and training. Indeed, with an appropriate aid, the learning of lip reading by the new methods, and by compensation in a variety of ways, seriously deafened individuals are today leading normal lives, the majority of their acquaintances unaware of the extent of their deficiency.

A false impression can easily be gained by the counselor of the ability of the deafened individual to succeed in jobs where normal hearing is required. Many of these individuals have negativistic tendencies, anti-social trends, and regressive behaviors as a result of their auditory deficiency, all of which may be quite unjustified and much of which may be remedied. Recent experience has shown that the social rehabilitation of the auditory defective is at least as important if not more important than restoring his hearing by arti-

ficial aid. Many individuals properly fitted with aids are still unsuccessful persons because their earlier acquired habits have not been replaced with correct social responses. Yet it is possible with enlightened instruction and assistance for these unfortunate tendencies to be overcome and for the individual to learn to enter into a new phase of living on the basis of a sense of accomplishment in overcoming a defect, and finally on the basis of establishing security in a good job and security in the acceptance and affection of his fellows.